ISSN: 2394-3661, Volume-2, Issue-1, January 2015

Comparison of Results of Calibration of Isolation Current Transformer by Conventional Method & Two Power Comparator Method

M. K. Mittal, J.C.Biswas, K.P.S.Yadav, A.S.Yadav, L.Sridhar, Manish Tamrakar, Shrikishan, R.P.Agarwal, S. S. Rajput

***Abstract*— This paper describes the calibration of Isolation Current Transformer by two methods, by conventional method and by two comparator based calibration method. A conventional method has limitations that we get fixed ratios and hence can go up to lower value of 1A. The uncertainties of the calibration system are in the order of 0.005 % for the ratio error and 0.01 crad for the phase displacement of the current transformer at 50 Hz. The power comparator based measurements can be done at test currents from 10 mA to 160A.**

***Index Terms*— Current Transformer, Power comparator, uncertainties**

I. INTRODUCTION

Isolation Current Transformers (ICTs) are three phase electronically error compensated current transformers with a ratio of 1:1 and primary currents from 10m A to 200 A . They are widely used in stationary energy meter calibration/ test systems to isolate the reference current path of the test system from the current path of the energy meters, which have to be tested on phantom loading system in the laboratory.

II. NEED OF MEASUREMENT:

The voltage and current paths of a conventional energy meter cannot be separated, since while connecting the meter on actual load, the meter draws voltages as well as current from the same phase terminal and the energy meter is sealed in general when it is received in the laboratory for testing purpose & cover cannot be opened. If the error of the Isolation current transformer is not included, we may get wrong results.

M. K. Mittal, Chief Scientist, AC Power & Energy and AC High Voltage & High Current Standard, National Physical Laboratory , New Delhi – 110012, India.

J.C.Biswas, Sr. Principal Scientist, AC Power & Energy Standard, National Physical Laboratory , New Delhi – 110012, India

K.P.S.Yadav, Sr. Superintendent Engineer, AC Power & Energy Standard, National Physical Laboratory , New Delhi – 110012, India

A.S.Yadav, Technical Officer , AC Power & Energy Standard, National Physical Laboratory , New Delhi – 110012, India

L.Sridhar, Technical Officer , AC High Voltage & High Current Standard, National Physical Laboratory , New Delhi – 110012, India

Manish Tamrakar, Technical Assistant, AC High Voltage & High Current Standard, National Physical Laboratory , New Delhi – 110012, India

Shrikishan, Technical Assistant , AC High Voltage & High Current Standard, National Physical Laboratory , New Delhi – 110012, India

R.P.Agarwal, Faculty of Electronics, Information & Computer Engineering, Shobhit University, Meerut – 25011.

S. S. Rajput, Chief Scientist and head, Material Physics and Engineering Division, National Physical Laboratory, New Delhi- 110012.

III. METHOD OF CALIBRATION:

Isolating current transformers (ICTs) are three phase electronically error compensated current transformers with a ratio of 1:1 and maximum primary currents from 10mA to 160A.

In a conventional method we have to use two high precision current transformers, since the ICT is 1:1 and if the primary current is given in 160 to 1A values, the two precision current transformers are to be connected in input and output side, so that we can reach to the same value on the output side of the transformers and can be compared by a Automatic/Current Instrument Transformer Test Set (AITTS/ CTTS).

While in a two comparator method two commercial high precision power comparators [5] are used to read the values of currents. The assumption at this stage is taken that the two comparators are of exactly same type(COM 3003 or COM 3000) so that we can take the phase difference between the two as nil.

The required ac current source is part of the stationary energy meter test system which is used for testing the energy meters having internally connected link between voltage and current points of the meter. In Fig 1 one ac source is shown which supplies the same voltage to the two comparators and therefore the voltage in the two comparators will be at the same phase while the current from the ac source is given to the input side of the ICT and in one of the comparator which is taken as < N> just to designate the reference comparator. The secondary side of the ICT will also be at the same current level since the ratio of ICT is 1:1. Now the current to the other comparator, which is taken as <X>, is given in series with the secondary side of the ICT

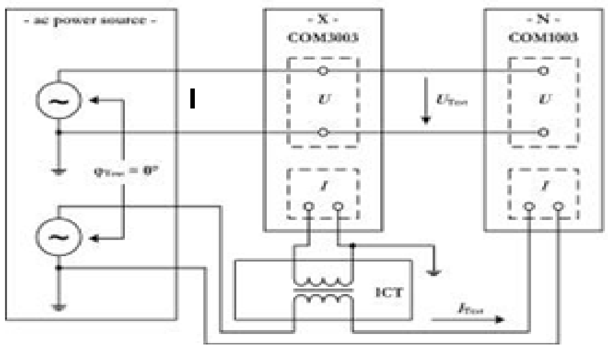
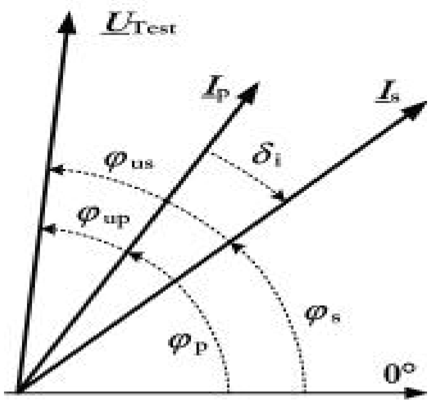


Fig. 1 connection of ICT with two comparator



Fig, 2 phasor diagram for phase displacement between Ip and Is

A. Connecting cables:

Proper copper connecting wires are used for making connections to the reference standards and isolation current Transformers

Environmental Conditions

Temperature : **(25 ± 1)°C**
Humidity : **(50 ± 10)%**

In the Fig. 2,e $\underline{U}_{Test}$ is the voltage given to the two comparators. Φ_P and Φ_S are the phases of the two currents, input current to ICT, I_P and output current from ICT, I_S and Φ_{UP} and Φ_{US} are the phase differences between the test voltage and input current to ICT, I_P and output current from ICT, I_S respectively. The ratio error is calculated by the magnitude of the two currents , Input to ICT and output from the ICT, while δ_i is the phase displacement of the ICT, i.e. the phase difference in the input and output currents of the ICT.

IV. RESULTS:

For the comparisons of the results from two methods, several readings are collected for different current values and keeping the voltage at reference value of 240V. After applying the correction for current values for both the comparators, we are sure that the difference in current values are data for calculating the ratio errors and the phase difference between the two currents would be phase error of the Isolation Current Transformer. To compare the results four tables have been formed. Table A shows the values taken by two comparator method. The ratio errors are calculated by dividing the two current values and subtracting the ideal value 1.0 . The phase errors are calculated by subtracting the phase of current of the 1st comparator from the phase of the 2nd comparator. The phase errors are calculated in minutes.

Current(A)	Ratio Error %	Phase Error (minutes)
120	-0.0037	-0.0491
5	-0.0030	+0.0326
1	+0.0206	+0.2639

Table A : Errors by two comparator method

Current(A)	Ratio Error %	Phase Error (minutes)
120	-0.0070	-0.1200
5	-0.0065	-0.0320
1	+0.0095	+0.0700

Table B: Errors by conventional method.

Current(A)	Ratio Error %	Phase Error (minutes)
120	-0.0002	0.0
5	-0.0004	0.0
1	-0.0005	0.0

Table C: Standard CT Errors

Current(A)	Ratio Error %	Phase Error (minutes)
120	-0.0026	-0.1000
5	-0.0027	-0.0870
1	-0.0092	-0.2210

Table D: Eltel CT errors

Current(A)	Ratio Error %	Phase Error (minutes)
120	-0.0042	-0.0200
5	-0.0034	+0.0550
1	+0.0192	+0.2910

Table E: Final Errors (B-C-D)

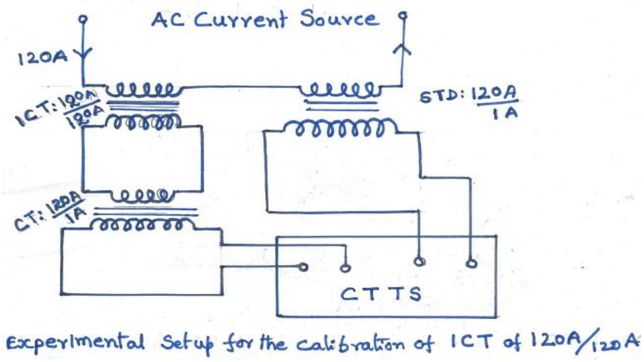


Fig 3: Calibration by conventional method

In the conventional method (Fig.3) , current is given to both Isolation current transformer as well as to a std. CT which gives output as 1 A. This is given to one terminal of a Current Transformer Test Set (CTTS). In the same way, since current in the output of the isolation current transformer would be same as the input current , we connect another CT (Eltel CT has been connected for example) whose output will again be at 1A level and this is given to the other terminal of the CTTS. The CTTS compares the two input currents which are at 1 A level and gives the ratio and phase errors. Table A shows the errors taken by two comparator method while the table B shows the errors taken by the conventional method in which two other CT,s are involved to step down the currents to 1A level.

Hence to compare the errors taken by the two method, we have to subtract the errors of table C & D from the table B errors to find the actual errors of the Isolation Current transformer. Table E shows these errors. Now if we compare the errors of table A and table E, we find they are comparable within the uncertainty limits which are 40 ppm for ratio and 0.10 minutes for phase.

ACKNOWLEDGEMENT

We are thankful to the staff of AC Power & Energy Standard and AC High Voltage and High Current standard for making different connections and taking the readings at different current and power factor values.

REFERENCES:

[1] Power comparator based on –site calibration of Isolating current transformers, MAPAN, Journal of metrology society of India, vol 24, no. 1, 2009 , pp 67-72

[2] Indian Standard Specification, ac Static Watthour Meters, Class 1 And 2, (IS-13779:1999)

[3] Indian Standard Specification, ac Static Transformer Operated Watthour And Var-Hour Meters, Class 0.2S And 0.5S (IS-14697:1999)

[4] W.J.M. Moore and P.N. Miljanic, The current comparator, IEEE Electrical Measurement Series, 4,Peter Peregrinus Ltd. London (1998)

[5] COM 3003, COM303-3 , COM3000, www.zera.de/products/meter-test/comparator-com3003

[6] Manual on Standardization of AC Static Electrical Energy Meters,, 304:2008

[7] International Standard, Electricity metering equipment (AC) General requirements, tests and test conditions (IEC 62052-11:2003-2)

[8] International Standard, Electricity metering equipment (a.c.) Particular requirements- IEC (62053-21:2003-01), Static meters for active energy (Classes 1 and 2)

[9] International Standard, Electricity metering equipment (a.c.) Particular requirements- IEC (62053-23:2003-01), Static meters for reactive energy (Classes 2 and 3)

M.K.Mittal did his B.E.with honours (Electronics & Communication from University of Roorkee (now IIT Roorkee) in 1974. And joined NPL (National Physical Laboratory) New Delhi. He did his M.Tech. (Controls & Instrumentation) from Indian Institute of technology (IIT) Delhi in 1987. Since 1994 he is working as Head of AC Power & Energy Standard. From 2012 he is working as Head of AC High Voltage & High Current Standards also. During 1992 – 1998, he visited PTB Germany and various other labs of Europe under PTB-NPL co-operation program. He attended CCEM and CCEM working group meetings at BIPM France as Director NPL's nominee in 2002. He is advisory member of BIS and CBIP Committees since 1989 and member of Metrology Society of India since 1991.

J.C.Biswas, did his B.Tech from IIT Kharagpur in 1991. He joined National Physical Laboratory, in 1992. He is expert in R & D related to Calibration and testing of AC Power & Energy Meters and also in power system as a whole. He attended several AdMet conferences and presented several papers in Calibration, testing and intercomparisons.

K.P.S.Yadav did his B.Sc. Engineering in Electrical from Z.H. College of Engineering & Technology, Aligarh Muslim University, in 1981. He worked as trainee engineer in Electronic Industries of India Ghaziabad 1983. He From Dec. 1981 to Feb. 1983. He then worked as Junior Engineer I in Kota thermal power station, Rajsthan Electricity Board up to June 1986 as In- charge of Electrostatic Precipitator, Extra High Voltage Transformer and control instruments. He worked as SDO/Deputy Secretary in JAl Sansthan from 1986 to 1996. He then joined CSIR and worked as SE and Sr, SE as head Engineering services division in CDRI Lucknow and Indian Institute of Petrolium, Dehradun . He worked as Sr. SE and head of Electrical Sub division and Horticulture in National Physical Laboratory till Feb.2012 and then joined AC Power & Energy Standard of NPLI, where he is working till date. He is responsible for calibration and testing job of AC Power & Energy Meters.

A.S.Yadav did his Diploma In Electronics and Electrical Engineering communication from Board of Technical Education Delhi in 1991, He joined IIT Delhi as Sr. Lab. Assistant. Afterwards he joined National Physical Laboratory in 1997 and is working here till now. He is expert in power & Energy meters tasting and calibration. He attended several AdMet conferences in Delhi and one APMP conference and presented papers on Calibration and Euramet.

L. Sridhar did his B.Tech in Electrical Engineering from Delhi College of Engg. He joined CSIR-National Physical Laboratory in Dec. 1996. He is working as a Senior Technical Officer in AC High Voltage & High Current Stds. of NPLI. His is presently responsible to Establish, Maintain and Upgrade the National standards of AC High Voltage ratios, AC High Current ratios, Capacitance and Tan δ Standards and for disseminating the traceability for instrument transformers and allied equipments upto 200kV and 5000A besides R & D work to establish the traceability of ac high voltage at NPLI through primary standard of Calculable Cross capacitor.

Manish Kr. Tamrakar did his M.Tech from IIT Delhi. He joined CSIR-National Physical Laboratory in August 2007. He is working as Technical Assistant in AC High Voltage & High Current Standards. His role is to establish, maintain and upgrade the National standards of AC High Voltage ratios, AC High Current ratios, Capacitance and Tan δ Standards and to contribute in ongoing R & D work in the group. He is involved R & D work to establish the traceability of ac high voltage at NPLI through primarry standard of Calculable Cross capacitor.

Shrikrishan did his Diploma in Electrical Engineering from BTE, Delhi. He joined CSIR-National Physical Laboratory in July 2009. He is working as a Technical Assistant in AC High Voltage & High Current Standards. His role is to establish, maintain and upgrade the National standards of AC High Voltage ratios, AC High Current ratios, Capacitance and Tan δ Standards and to contribute in ongoing R & D work in the group for the establishment of traceability of High voltage to the calculable capacitor.

R.P.Agarwal received his B.Sc. degree form Agra University, B.E. degree in E&CE with hons. In 1967 and M.E. degree from Poona University in 1970. He received his Ph.D. from University of Newcastle upon Tyne, UK, 19977, under common wealth scholarship programme. Dr. R.P.Agarwal joined the Department of E&CE, IIT Roorkee, as lecturer in 1970, where he worked as professor and Dean till 2009. Thereafter he worked as Vice-Chancellor of Bundelkhand University, Jhansi, UP and Dr. H.S.Gaur Central University, Sagar, M.P. He is currently working as Vice-Chancellor of Shobhit University, Meerut, UP India. He has published over 150 research papers in journels and conferences of repute and guided number of Ph.D. and M.Tech. students. His research interests include computer engineering, signal processing system and VLIS.

***S*.S. Rajput** was born on July 1, 1957, at village Bashir Pur, District Bijnor UP India. He received his B. E. in Electronics and Communication Engineering and M. E. in Solid State Electronics Engineering from University of Roorkee, Roorkee, India in 1978 and 1981 respectively and was awarded University gold medal in 1981. He earned his Ph.D. degree from Indian Institute of Technology, Delhi in 2002 and his topic of research was "Low voltage current mode analog circuit structures and their applications". He joined National Physical Laboratory, New Delhi, India as Scientist B in 1983, where he is presently serving as Chief Scientist. He was Dean and Professor in ABV-IIITM, Gwalior from June 2007 to May 2010. He has worked for the design, development, testing and fabrication of an instrument meant for space exploration under the ISRO-NPL joint program for development of scientific instruments for the Indian Satellite SROSS-C and SROSS-C2 missions. His research interests include low voltage analog VLSI, instrument design for space applications, Digital Signal Processing, Fault tolerant design, and fault detection. He has chaired the many sessions in Indian as well as International conferences. He is Fellow member of IETE (India). He has been awarded best paper award for IETE Journal of Education for the year 2002. He has delivered many invited talks on Low Voltage Analog VLSI. Few tutorials have been presented in International Conferences on his Research Work. He has more than 80 publications in national and international journals.